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ABSTRACT

Methodologies were proposed for combining background and aptitude and/or achievement information in an approach to the classification problem using the concept of under- and overachievement. The methodologies were applied to independent samples from four high school curricula. The results suggest that when past achievement and/or aptitudes were held constant (1) groups characterized by overachievement in all four curricula had similar backgrounds as defined by their level and pattern of responses to five biographical variables, (2) groups characterized by underachievement in the four curricula appeared to have similar response patterns but had more variation with respect to level and (3) underachieving groups regardless of curricular chioce reported that they spent more time on extracurricular technological projects than did overachieving groups. To a somewhat lesser extent underachievers tended to have fathers who discouraged their going on to college and they (the underachievers) also tended to spend more time on extracurricular reading. (Author)

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RB-71-30

CULTURAL CHARACTERISTICS AS A MODERATING INFLUENCE ON EXPECTED ACHIEVEMENT WITHIN A CURRICULUM CHOICE

(Growth Study Paper #58)

Donald A. Rock and Franklin R. Evans

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Educational Testing Service
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Cultural Characteristics as a Moderating Influence on Expected Achievement within a Curriculum Choice

(Growth Study Paper #58)

Donald A. Rock and Franklin R. Evans

Abstract

Methodologies were proposed for combining background and aptitude and/or achievement information in an approach to the classification problem using the concept of under- and overachievement. The methodologies were applied to independent samples from four high school curricula. The results suggest that when past achievement and/or aptitudes were held constant (1) groups characterized by overachievement in all four curricula had similar backgrounds as defined by their level and pattern of responses to five biographical variables, (2) groups characterized by underachievement in the four curricula appeared to have similar response patterns but had more variation with respect to level and (3) underachieving groups regardless of curricular choice reported that they spent more time on extracurricular technological projects than did overachieving groups. To a somewhat lesser extent underachievers tended to have fathers who discouraged their going on to college and they (the underachievers) also tended to spend more time on extracurricular reading.

Cultural Characteristics as a Moderating Influence on Expected Achievement within a Curriculum Choice[1]

(Growth Study Paper #58)

Donald A. Rock and Franklin R. Evans

With the increased emphasis on efficiency in education today, it becomes of great practical concern to know what determines how much a student profits from his curriculum choice. It is of considerable importance to be able to define and describe those measurable characteristics of an individual's background that may interact with his achievement in his selected curriculum. Such information is, of course, necessary for effective and knowledgeable guidance and placement decisions.

The placement problem is in general concerned with exposing individuals to those "treatments" from which they will most profit subject to certain constraints within the system such as availability of treatments, etc. This is the traditional classification problem. In its purest sense the problem is unsolvable since in general an individual will appear in only one treatment group so criterion information is not available for him on all treatments. Thus, we must develop a methodology which enables us to make educated guesses about whether or not a person would have done better if he were indeed in a different treatment classification. This study will propose and empirically test techniques for arriving at compromise solutions to typical classification problems.

The major objectives of the study reported here were to arrive at tentative answers to the following questions:

(1) If the input with respect to past achievement as measured by a battery of standardized tests is held constant (within a curriculum choice)

will it be possible to identify subgroups (i.e., groups of individuals having homogeneous profiles on background information) which show significantly greater or lesser achievement on the average?

(2) Are the same background patterns always associated with over-achievement and conversely underachievement independent of curriculum choice? That is, are the cultural patterns with respect to both level and shape associated with individual under- or overachievement invariant across curricula?

(3) If (2) above is not true or only partially true and the attributes for success and/or failure are not consistent across curricula, then it is hoped that the background profiles of those individuals who do considerably less well than one would expect from their aptitudes may, however, have similar profiles to a success group in another curriculum. For example, success may be "achieved" via many avenues while one's channels to failure may be more or less limited or vice versa. It should be made clear here that our terms success and failure within a curriculum are only relative and simply reflect whether or not a group's performance with respect to school grades is better (or worse) on the average than would be predicted from their inputs on past achievement test scores.

Method

It is here that we choose to deviate from the more "traditional" extreme group research methodology in favor of using taxonomic techniques which form "natural" groups of individuals which are characterized by frequently occurring background patterns as defined by their responses to biographical items. That is, it was felt that if one can divide the total

sample into homogeneous subclasses of individuals rather than define groups which are extreme with respect to performance on some criterion of interest, the prognosis for the generalization of any subsequent findings would be significantly improved.

Thus the focus of this study is on the formation of clusters of individuals within each curriculum according to the similarity of their multidimensional response patterns on biographical data. Then the various groups of individuals are examined with respect to their relative level of under- and overachievement.

If the cultural or background patterns associated with under- and overachieving groups are found to differ across curricula, the question can be asked, "Is there an underachieving group in one or more curricula, which is similar with respect to background patterns to an overachieving group in another curriculum?" If there is indeed sufficient group overlap, we may expect to find a substantial number of individuals in the underachieving group who are more like the overachievers in another curriculum than they are like the average underachievers in their own group. That is, if we plotted the points for each individual in the multidimensional space defined by the background variables, the points of many of the underachievers would lie closer to the centroid (locus of maximum density) of the overachievers than they would to the centroid of their own groups.

The formation of homogeneous subgroups within curricula was accomplished through the use of a multiple moderator technique (Rock, Barone, & Linn, 1967). This technique iteratively searches among a set of background variables (up to a maximum of five) for those particular variables, singly or in combination, which define groups which in turn are characterized by differing relationships between criterion and a system of predictor

variables. The grouping procedure used in the moderated regression is a modification of Ward's (1963) hierarchical clustering procedure applied to five background response patterns. The procedure begins with g groups and then forms g-1 groups selectively collapsing groups which maximize the between to within group sum of square and continues until the researcher notices a large increment in the within group sum of squares (indicating the combining of two rather dissimilar groups) and/or until the number of individuals within the smallest group becomes large enough to provide satisfactory future statistical estimates.

Depending upon the particular objective of the study, any one of three objective functions may be used with this technique. Consistent with the purpose of this study the objective function was selected which was designed to identify particular groups of students characterized by within group homogeneity with respect to backgrounds, yet for whom the overall regression equation based on a battery of achievement tests results in overpredictions or underpredictions. It does this by grouping individuals according to similarity of patterns of responses to background questions and computing the relationships between the mean grade point average (GPA) that had been predicted and the mean GPA that had actually been obtained by that group. Subtraction of the predicted values from the obtained values yields a mean residual which is an index of the amount of overprediction (a negative residual) or underprediction (a positive residual) which characterizes that particular group.

This function enables one to identify the groups which yield the largest absolute difference in mean residual values. This will result in a system of subgroups, two of which are of particular interest; one that

is characterized by overachievement, the other by underachievement (Flaugher & Rock, 1969).

Having formed clusters of individuals who are characterized by over- and underachievement within each curriculum we then need methodology to measure the relative similarity or dissimilarity of the background profiles of the various groups. Since groups may be formed on the basis of up to five background variables, the problem becomes one of estimating the overlap between the multivariate distribution associated with each group. The centour concept as described by Cooley and Lohnes (1962) and Rulon, Tiedeman, Tatsuoka, & Langmuir (1967) appears to be well suited for this problem.

The centour score provides a good index of the extent to which an individual or group resembles another group where the second group's means and dispersions are known. The centour method may, of course, be generalized to any number of variables. The centour score is the probability of obtaining a larger chi-square (χ^2), thus when an individual's scores are compared with the mean scores associated with a particular group with a known dispersion matrix, the larger the χ^2, the less likely an individual having said scores would be a member of that population. More rigorous treatments of this application of the maximum likelihood classification procedures may also be found in Rao (1952) and Tatsuoka (1957).

Samples

Data for this study were taken from the Study of Academic Growth and Prediction (Hilton & Myers, 1967). Four high school curricula were selected for analysis. The four curricula were academic, vocational, business, and general. In order to get a fairly large sample with complete data cases the subjects were selected from three different high schools. The sample

sizes within each curriculum were: academic, 550; vocational, 354; business, 314; and general, 276.

Predictors

The predictors were scores on five of the Sequential Tests of Education Progress (STEP) which were administered when the students were in the ninth grade. The five predictor scores included mathematics, science, social studies, reading, and writing. The criterion was senior rank in class which was subsequently adjusted (Angoff, 1961) using the individual's School and College Aptitude Test (SCAT) scores,[2] in order to reduce differences among schools in grading practices which may be due to differences in ability inputs.

Background Variables

The background or moderating variables were selected on the basis of past research (Rock, 1968) which seemed to indicate their potential for acting as measures of motivation. Three of the five variables in particular have demonstrated moderator characteristics. One of these variables was an "Environmental Participation" scale (Moderator 1) which was constructed in an effort to yield estimates of the exposure of the individual to typical middle class experiences and environmental stimulation. It is hypothesized that poverty of experiential stimulation rather than socio-economic class would have the greater moderating effect on the regressions. The remaining two "motivation" type variables were standard "family press" type biographical items which were concerned with the parent's attitude towards school achievement (Moderator 2) and the father's attitude toward continuing on to college (Moderator 3). The fourth biographical variable was concerned with the amount of nonschool related reading done. More

specifically this scale consisted of items asking about the number of books read in the areas of current events, biographies, music, art, poetry, science, etc. The fifth (potential moderator) asked about time spent on, as well as interest in, home economics, vocational or technological type activities such as repairing cars, machinery, etc.

The moderated regression technique was run independently within each curriculum sample. Since the sample sizes were not sufficiently large to allow splitting into random halves within curriculum, stability of the results must depend on whether or not the various success and/or failure patterns could be replicated across curricula.

Results and Discussion

Table 1 presents an 8 x 8 matrix of centour scores indicating which of the over- and underachieving groups are most similar or dissimilar to each other based on their group means on the five biographical variables. Within each curriculum of Table 1 there is a column of centour scores for

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Insert Table 1 about here

---

the overachieving group and the underachieving group. An entry c_{jk} in the matrix of centours indicates the centour score associated with group k in the group j dispersion. For example, c_{31} indicates that an individual having group 1 mean scores, an overachiever in the academic curricula, is closer to the centroid of group 3 than 98% of the individuals in group 3. Conversely c_{13} indicates that an individual having group 3 means lies closer to the center (centroid) of group 1 than do 89% of the members of group 1. More simply, if you wish to know which groups the underachiever in the vocational curriculum is most like, you would simply go down column 4

noting the largest entries. Thus high values on the off-diagonals indicate a high degree of overlap between the corresponding groups. Lack of symmetry in the appropriate off-diagonal elements, e.g., $c_{13} \neq c_{31}$ is due to differences in dispersions for the paired groups.

A closer inspection of Table 1 shows that in general the overachieving groups show considerable similarity with respect to response patterns on the background items. That is the overachievers within any one curriculum were far more like the overachievers in another curriculum than the underachievers in their own or any other curriculum. In 12 possible comparisons, i.e., the overachieving group from each one of four curricula with the overachieving groups in the remaining three curricula, 10 yield centours in excess of 80. It was also encouraging to note that with the possible exception of the general curriculum, the centour scores indicate that the background patterns for the overachievers in any one curriculum were considerably dissimilar to those of the underachievers when past achievement is held constant.

In an attempt to present a more familiar index of the extent of separation of the under- and overachievement groups within curriculum than provided by the centour score, multiple correlations were computed between a criterion of group membership and scores on the five background variables. The multiple correlations were .82, .88, .81, and .77 for the academic, vocational, business, and general curriculum samples respectively. As the centours also indicated the background variables do significantly discriminate between the under- and overachiever within curriculum.

At first glance, there appears to be no consistent background pattern associated with the underachievers. However, as we shall see later on the low centours between underachieving groups are primarily due to differences

in level rather than in the patterns of responses to the background questions. The consistency in the similarity of backgrounds among the overachievers with respect to both pattern and level as compared to the relative lack of similarity among the underachievers suggests that the "paths to success" may be somewhat limited while there are more "roads" to underachievement.

Table 2 shows the centroids or vector of means for each of the over-

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Insert Table 2 about here

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and underachievers within curriculum. Three of the five background means demonstrate a consistent pattern which is replicated over all four curricula. That is, for all four curricula when past achievement is held constant the underachieving (1) tend to spend more time on nonschool related reading, (2) tend to have fathers who discourage their continuing on to college (high scores indicate less encouragement), and (3) spend more time on vocational or technological type activities. It should be pointed out here that it is the multidimensional pattern of the three background variables rather than any one alone which differentiates the under- from the overachievers. In fact, when individuals are grouped according to the level of extracurricular reading alone, the more active readers tend to overachieve in both the academic and vocational curriculum. There is no such clear differentiation in the general or business curriculum. It is possible that the incongruous combination of interest in nonschool related reading while operating within a relatively negative family press situation may prove somewhat debilitating with respect to achieving the expected academic performance. It also should be noted here that reading achievement as measured

by the STEP reading test has been held constant within curriculum in the model used in this analysis. This, of course,suggests that given the same reading achievement level, those individuals who report spending considerable time on nonschool related reading in conjunction with the previously specified pattern on background variables achieve less well than expected. As a result of looking at such complex interactions one begins to understand why our relatively oversimplified standardized test battery prediction models may often fall short of the desired accuracy for any one given subset of the population of interest.

Indication of the relative contribution of the three background variables to the discrimination between groups characterized by over- and underachievement within curriculum were obtained from inspection of the standardized partial regression weights from the multiple correlational analysis referred to earlier. The fifth moderator, time spent on vocational or technological extracurricular activities, had a statistically significant regression weight in all four curriculum samples. Reported time spent on nonschool related reading and father's attitude towards continuing higher education were statistically significant in three of the four and two of the four curriculum samples respectively. The underachievers appear to spend considerable time on technological activities and reading material that evidently are not rewarded in the normal school grading practices. The fact that interest in vocational or technological activities appears to be the best discriminator between under- and overachievers suggests that simple sex differences may be an equally potent predictor of under- or overachievement. Thus sex was coded and entered into the prediction equation with the five grouping variables. In none of

the four curricula was sex found to be a significant predictor. It would seem that in this study the extent of one's interest in technological activities is a far more important variable than knowledge of sex group membership for predicting under- and overachievement.

The fact that underachievers tend to report a lack of "family press" towards continuing education has also been reported in a previous study of over- and underachievement (Rock, 1968). A high level of extracurricular activities of a more general nature were found to be related to underachievement in another earlier study by Flaugher and Rock (1969). Further inspection of Table 2 indicates that although underachievers demonstrate a consistent pattern with respect to three of the background variables, the relative levels vary from curriculum to curriculum. This, of course, contributes to the lower centour scores between the underachievers.

Since most of the overachieving groups looked only like other overachieving groups the attempt to find an underachieving group which looked like an overachieving group in another curriculum was not especially successful. However, the underachievers in the academic curriculum did show extensive overlap with respect to background response patterns with the overachievers in the vocational curriculum. That is, inspection of Table 1 indicates that the centroid of the academic underachievers is closer to the centroid of the vocational overachievers than approximately 83% of the members of that group. However, any meaningful comparison across curriculum would have to include aptitude information in addition to background patterns. That is an underachiever in the academic curriculum could have the same background pattern as an overachiever in the vocational curriculum yet his aptitudes may still be inappropriate. Since there was

no opportunity for replication of this finding in this study, these results can only serve as a means for future hypothesis generation.

Conclusions

Methodologies were proposed for combining background and aptitude and/or achievement information in an approach to the classification problem using the concept of under- and overachievement. The methodologies were applied to independent samples from four high school curricula. The results suggest that when past achievement and/or aptitudes were held constant (1) groups characterized by overachievement in all four curricula had similar backgrounds as defined by their level and pattern of responses to five biographical variables, (2) groups characterized by underachievement in the four curricula appeared to have similar response patterns but had more variation with respect to level and (3) underachieving groups regardless of curricular choice reported that they spent more time on extracurricular technological projects than did overachieving groups. To a somewhat lesser extent underachievers tended to have fathers who discouraged their going on to college and they (the underachievers) also tended to spend more time on extracurricular reading.

The results also suggest that the "natural" grouping technique proposed here may increase the possibility of replication from sample to sample while not leading to particularly exciting or extreme results within any one given sample.

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Footnotes

[1]This research was performed pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare.

[2]Further information on the STEP and SCAT test batteries can be obtained by writing to:

Cooperative Test Division
Educational Testing Service
Princeton, N. J. 08540

TABLE 1

CENTOURS OF THE CENTROIDS

ON BACKGROUND VARIABLES

	Academic		Vocational		Business		General	
	Over-achievers	Under-achievers	Over-achievers	Under-achievers	Over-achievers	Under-achievers	Over-achievers	Under-achievers
	1	2	3	4	5	6	7	8
	N=203	N=134	N=124	N=94	N=92	N=81	N=88	N=75
1	1.000	.112	.890	.000	.962	.362	.999	.113
2	.128	1.000	.700	.027	.361	.000	.179	.043
3	.983	.833	1.000	.000	.076	.292	.982	.170
4	.022	.064	.062	1.000	.016	.006	.017	.066
5	.429	.013	.281	.000	1.000	.004	.911	.000
6	.565	.037	.250	.000	.268	1.000	.439	.910
7	.998	.338	.964	.000	.996	.137	1.000	.011
8	.626	.457	.631	.017	.516	.954	.575	1.000

TABLE 2

Group Means for Over- and Underachievers within Curriculum

	Academic		Vocational		Business		General	
	Over-achievers	Under-achievers	Over-achievers	Under-achievers	Over-achievers	Under-achievers	Over-achievers	Under-achievers
M_1	49.05	40.89	45.97	44.77	44.91	62.21	48.41	57.08
M_2	46.61	55.66	50.91	47.77	48.04	44.88	48.09	48.05
M_3	45.00	46.49	45.42	66.81	42.48	45.18	43.81	48.07
M_4	45.62	51.59	45.35	46.62	44.82	50.65	44.22	54.78
M_5	43.38	52.57	49.26	57.18	46.67	51.97	45.45	59.14
Mean Residuals	.62	-1.07	.97	-.74	1.01	-1.07	.47	-.58
Standard Error of Mean Residuals	.4646	.5717	.7756	.8907	.7393	.7896	.8209	.8891